

tending down into a hydraulic cylinder 12 to which water under great pressure may be supplied as is common in presses of this type. The upwardly moving plunger 12 is provided on the top with a mold 13 having a recess 14 which receives the powdered tungsten or other finely divided material and in which the bar is formed. The size and dimensions of the recess of the mold can be varied and will depend upon the dimensions of the bar which is to be formed. The powder is compressed in the mold into the form of bar by a die 16 which is held up against a filler block 17 attached to the head 10, by means of coil springs 18 guided and supported by vertical rods extending between the head of the die and the top of the mold.

I provide around the mold a vacuum chamber, and preferably this chamber is composed of upper and lower telescopic cylinders 19 and 20 carried by the head 10 and plunger 11, respectively, and completely surrounding or inclosing the die, mold and tungsten or other material being compressed when the plunger is elevated to compress the material. The vacuum is formed in the chamber by sucking or withdrawing the air therefrom by means of a suitable suction pipe 21 which will be connected to an ordinary suction or vacuum pump not shown. It will be understood, of course, that any suitable means may be provided for forming air tight joints between the telescoping parts of the cylinders and at other points, such as points of attachment of the cylinder sections with the head and plunger of the press.

Before the powder is compressed the air is withdrawn, forming a vacuum in and around the finely divided material, die and mold, the pump being set in operation so as to form the vacuum not only prior to the compression of the material but also during the interval that the material is being compressed, which is usually several minutes. By thus removing the air from the material being compressed a much finer powder or a more finely divided material can be utilized and much greater pressure can be applied than was heretofore possible, and in consequence a very much denser bar can be obtained. If tungsten is being produced, after the bar is formed as above described, it is then subjected to the sintering process, swaging and heating, and there is obtained a solid metal denser than that obtained heretofore and one having properties more suitable for many uses.

The springs 18 are employed to hold the die from the material being compressed until the air is removed. It is very important that the vacuum be produced in the

chamber before any considerable pressure is created on the material for otherwise the air could not be completely removed from the material. Additionally the lower part of the die in the mold prevents the fine powder from fluffing out of the mold as the vacuum is produced, although it does not prevent the escape of air from the mold, there being a very slight clearance between the sides of the die and mold.

The degree of pressure which is applied in the manner above explained will depend somewhat upon the materials being operated on. In the production of tungsten the pressure will be as great as the die and mold will stand, which will be between thirty and forty tons per square inch.

After the brick or ingot is formed by the method above described, precisely the same steps may be employed as are now employed to form the solid ductile tungsten from the bar, or any other steps which will produce the desired results may be carried out, the essential feature of my process being the removing of air or other gas from the finely divided material or from the bar before and while the material is being compressed, regardless of the particular steps if any which are subsequently carried out, and regardless of the particular material being operated on.

Having thus described my invention, what I claim is:—

1. The method of forming a bar which comprises removing air from a quantity of finely divided material and subjecting the material to pressure.

2. A step in the process of forming a solid body which comprises compressing a quantity of finely divided material *in vacuo*.

3. A step in the method herein described, which comprises treating powdered material so as to form a bar in the absence of air.

4. The method of forming a bar from material in finely divided form, which comprises first removing air from a quantity of material and then subjecting the material to pressure.

5. The method of forming solid metal tungsten from tungsten in finely divided form, which comprises withdrawing air from a quantity of the finely divided tungsten and subjecting the same to pressure.

6. The method of forming solid metal tungsten, which comprises compressing a quantity of tungsten in powdered form *in vacuo* so as to form a bar and then heating the bar and swaging the same.

In testimony whereof, I hereunto affix my signature.

JOSEPH A. WILLIAMS.